

Coastal Ocean Optical Properties in Santa Barbara Basin - Blooms & Plumes

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LONG-TERM GOALS

Our primary goals are 1.) to accurately model the optical properties of Case II waters in order to estimate the respective contributions and fluxes of biogenic and terrigenous material, and 2.) to develop algorithms for the optical characteristics of Case II waters for comparison and testing with the recently launched SeaWiFS satellite.

OBJECTIVES

This work is closely linked to other ONR and NOAA-funded research in Santa Barbara Basin with the objective of this work primarily focused on the mooring observations. Our objectives are to:

1. obtain a multi-platform (ship, mooring, and satellite) time series record of the spatial and temporal variability of sediment-producing processes within the Santa Barbara Basin (SBB) to provide input data for our models,
2. link the in situ bio-optical data to contemporaneous SeaWiFS satellite data to

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construct an appropriate data base for Case II ocean color algorithm development,

3. refine existing algorithms for estimation of surface pigment concentrations (Chl-a) and, as appropriate, near-surface terrigenous material,
4. model these Case II waters in order to estimate both terrigenous and marine constituents and their respective fluxes for comparison with the high resolution sediment record from the SBB.

The time series and satellite data allow unprecedented space/time coverage and optical documentation of SBB Case II water types, providing a unique opportunity to develop and refine optical models. A further scientific objective is to utilize these data and the resultant models to quantitatively link surface processes with the SBB layered sediment record, which contains one of the most well-preserved and finely detailed climatic records in the world. The record permits biannual resolution and thus provides a direct link to the sediment-producing physical and biogeochemical processes in the waters above.

APPROACH

Our approach is interdisciplinary, combining optical (Smith, Siegel), physical (Washburn, Siegel) and biological (Brzezinski, Smith) oceanography with a terrestrial (geomorphology and sediment supply, Mertes) component. We use a multiplatform sampling effort (Smith et al., 1987) to collect the bio-optical and relevant ancillary data necessary to model Case II waters. The focal point of our sampling strategy is the UCSB surface-to-bottom mooring. Two subsurface optical sensors (BSI MER-2020's) at 5m and 15m collect downwelling irradiance and upwelling radiance measurements at SeaWiFS-equivalent wavelengths (410nm, 441nm, 488nm, 520nm, 565nm, and 765nm), and a surface unit measures downwelling irradiance at 410nm, 441nm, 488nm, and 560nm. The instruments sample every four minutes, yielding a detailed record of short-term diurnal variability in addition to longer-term seasonal change. The high sampling rate and extensive deployment allow an assessment of bio-optical changes over time scales from several minutes to about a year. Other mooring instrumentation includes a temperature/salinity probe and a recently added transmissometer. In addition, the mooring is equipped with a GPS-radio modem that provides "real-time" contact, relaying the mooring position and selected surface water properties at specific time intervals.

The continuous record collected by the mooring is consistently validated and augmented through bi-weekly shipboard sampling and extensive satellite imagery. Prior to mid-1996, relatively shallow (100m) CTD and optical profiling (PRR) casts were conducted at the mooring site from a 15' Boston Whaler. Since mid-1996 sampling has been conducted from a 56' NOAA vessel due to the establishment of a mutually beneficial relationship with the Channel Islands National marine Sanctuary (CINMS). The larger platform has enabled the program to extend the transect across the Channel, increase the number of sampling stations to seven, and routinely conduct CTD casts to 450m at the mooring. The transect crosses the main circulation gyre patterns of the SBB and thus ensures a gradient of optical water types. Presently, a wide variety of optical, physical, and biological parameters are measured at each station, including OFFI-type profiles with PRR (SeaWiFS bandwidths plus PAR) and PUV (305, 320, 340, 380nm, plus PAR); CTD, beam-c and stimulated fluorescence profiles; full-spectral profiles from 350-700nm using an ASD instrument; surface downwelling irradiance and upwelling radiance at 7 SeaWiFS wavelengths using a TSRB; water column measurements of particulate carbon, particulate nitrogen, lithogenic (terrigenous) silica, biogenic silica, chl-a and nutrient

(nitrate, phosphate, silicate) concentration; and measurement of total suspended particulate material (TSM).

The mooring and shipboard sampling program are complemented by acquisition and analysis of satellite imagery, using the UCSB Terascan system (AVHRR and SeaWiFS data) as well as higher resolution Landsat imagery. We currently receive multiple AVHRR passes each day; these data are invaluable in placing the mooring data within the broader space/time context of the complete basin and its adjoining waters. High resolution Landsat imagery has been acquired during and after storm events in order to track the subsequent sediment flow into the SBB. These images are essential for understanding the processes associated with terrigenous input to the system and its contribution to optically-active components in the water column.

Each of the bio-optical data sets (continuous mooring, periodic transects, and daily satellite imagery) is a valuable time series of bio-optical information. In addition to these time series observations, two process-oriented cruises are carried out each year (see below). Combined, this multiplatform data set provides a comprehensive picture of the spatial and temporal variability of the optical, physical, and biological characteristics of the Case II waters.

WORK COMPLETED

During the past year the moored optical instruments were deployed until October and then removed. Data recovery rates for this past year have not yet been determined. Optical profiling observations continued to be conducted on roughly a twice monthly basis, deploying the instruments listed in the preceding section. In addition, two multi-day data collection cruises (February 11-13 and October 13-19, 1998) were conducted.

RESULTS

The surface flow in Santa Barbara Basin (Hendershott & Winant, 1996) has been summarized in terms of a few synoptic patterns. These patterns are the conceptual analogue of the atmospheric synoptic states and for the SBB they provide a first order summary of flow regimes and corresponding water masses. In turn, these physical processes lead to respective hydrographic conditions which provide the setting in which characteristic optical properties are embedded. For example, biogenous and terrigenous material have distinctly different optical properties with distinct spectral characteristics. Thus, our multi-platform physical, biological and optical data permit the optical identification of characteristic water masses which, in turn, permit synoptic "predictive" capability for the optical properties. In addition, examination of relationships between K and water mass types at the mooring shows upper-layer optical changes consistent with the variability of different water masses. In particular, K values increase from 0.2 m^{-1} to approximately 0.5 m^{-1} during January through June, the period of maximum sediment influx and phytoplankton growth. Further analysis is focused on the link between these different optical signatures and the particular physical and biological characteristics of the water masses.

IMPACT/APPLICATION

Though relatively small in area, Case II waters are representative of the coastal waters and thus are of a significance disproportionate to their relative size. Coastal waters provide high biological production, offer key transportation and supply routes, and figure prominently in national security issues, making them among the most important waters of the world's oceans. Their optical properties are relatively poorly documented, understood, and modeled. Our goal is to accurately model the optical properties of these waters in the context of physical water mass types which will have both scientific value and important implications for optical sensor applications in these Case II waters.

TRANSITIONS

Our observations provide "real-time" estimates of terrigenous and biogenous flux to the sediment load, which will be compared with sediment cores from the SBB, thus providing a "direct link" between surface fluxes and deposition to the sea floor in an area where the paleo record permits biannual resolution. Our observations, in concert with those related projects (see below) provide local marine managers (CINMS) with long-term observations for assessing annual and interannual variability in the local marine ecosystem.

RELATED PROJECTS

Data are shared with researchers working under the NOAA-sponsored Coastal Ocean Program, in conjunction with the NOAA Channel Islands National Marine Sanctuary (CINMS) office, to determine the sources and causes of sediment plumes and phytoplankton blooms in the Santa Barbara Channel and their physical and bio-optical characteristics.

REFERENCES

- Booth, C.R. & R.C. Smith, Moorable spectroradiometer in the Biowatt experiment, in *Ocean Optics 9, Proc. SPIE Int. Soc. Opt. Eng.*, edited by M. Blizard, 176-188 (1988).
- Harms, S., and C.D. Winant, Characteristic patterns of the circulation in the Santa Barbara Channel. *J. Geophys. Res.*, 103(C2), 3041-3065 (1998)
- Henderschott, M.C., and C.D. Winant, The circulation in the Santa Barbara Channel, *Oceanography*, 9(2), 114-121 (1996)
- Mertes, L.A.K., M.O. Smith & J.B. Adams, Estimating sediment concentrations in surface waters of the Amazon River wetlands from Landsat images, *Remote Sensing of Environment*, 43, 281-301 (1993).
- Morel, A. & L. Prieur, Analysis of variations in ocean color, *Limnol. Oceanogr.*, 22 709-722 (1977).
- Smith, R.C., O.B. Brown, F.E. Hoge, K.S. Baker, R.H. Evans, R.N. Swift & W.E. Esaias, Multiplatform sampling (ship, aircraft, and satellite) of a Gulf Stream warm core ring, *Appl. Opt.*, 26, 2068-2081 (1987).

Smith, R.C., K.J. Waters & K.S. Baker, Optical variability and pigmentbiomass in the Sargasso Sea as determined using deep-sea optical mooring data,*J.G.R.*, 96, 8665-8686 (1991).

Smith, R.C., B.B. Prezelin, K.S. Baker, *et al.*, Ozone depletion:Ultraviolet radiation and phytoplankton biology in Antarctic waters,*Science*, 952-959 (1992)

Washburn, L. & L. Armi, Observations of frontal instabilities on an upwelling filament, *J. Phys. Oceanogr.*, 18, 1076-1092 (1988).

Waters, K.J., R.C. Smith & M.R. Lewis, Avoiding ship-induced light-fieldperturbation in the determination of oceanic optical properties,*Oceanography* 3, 18-21 (1990).

Waters, K.J., R.C. Smith & J. Marra, Phytoplankton production in the Sargasso Sea as determined using optical mooring data, *J.G.R.*, 99, 18,385-18,402 (1994).